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OPERATIONS AND MANAGEMENT OF THE NATIONAL PLANT GERMPLASM SYSTEM IN JAPAN

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After a remarkable success was performed in varietal improvement of major crops since 1930's, our country was faced irreparable losses of plant materials especially in rice, soybean, wheat and barley. The value of landraces was understood and had as to be preserved in the future materials. Researchers of the various breeding groups then made efforts for safe conservation of their materials.

Rapid modernization of agricultural practices and development of transportation made further attacks on the genetic erosion even in vegetables and minor crop species since 1960's. The time was then ripe for scientific reform on plant breeding in universities, public organizations as well as in the institutes under the Ministry of Agriculture, Forestry and Fisheries (MAFF). Establishment of a new system for the research required a new organization and budget and network systems which could be coordinated with introduction, collection, evaluation, preservation, distribution and utilization of plant genetic resources.

1. The MAFF Genebank System

The Genetic Resources Center of MAFF was established in the National Institute of Agrobiological Resources (NIAR, Tsukuba) in December 1986, by reorganizing the former Department of Genetic Resources. The former MAFF Genebank Project, which was started in 1983, has been acclerated to solve urgent problems in overall management of genetic resources.

A 10-year plan of the MAFF Genebank Project includes not only plants but also microorganisms, animals, forest trees, and fisheries organisms. NIAR is the central organization for plants, microorganisms and animals. These three areas are coordinated by the Genetic Resources Coordinator in the Center. NIAR's Genetic Resources Center is in this way playing a uniting role in getting close cooperation with co-working research organizations.

2. Network of Plant Genctic Resources in MAFF

The MAFF Genebank consists of a National Center (NIAR) and 15 Sub-banks located throughout Japan. Sub-banks are in 15 institutions, i.e., 13 National Research institutes. including NIAR, the National Center for Seed & Seedlings, and the National Livestock Breeding Center, as shown in Table 1. They are assigned specific crops, and share research activities on collection, evaluation and preservation of vegetatively propagated plants, multiplication of plant materials, and development/utilization of new breeding materials, as shown in Table 2. Prefectural institutes of 43 research units are connected to the network of the Project by special assignment with MAFF, covering exploration and collection abroad, as well as evaluation and multiplication of specific crops.

Crop species or plant groups in the Project are practically divided into 12 groups i.e., rice, wheat/barley, tuber crops, legumes, miscellaneous small grains/industrial crops, forage crops, fruit trees, vegetables, ornamental plants, tea, mulberry and tropical plants. Thus, 12 curators have been appointed for each plant group, as shown in Table 3. They belong to various institutes as a representative of each plant group, making annual plans, long term schemes for evaluation, documentation and collection of plant genetic resources as well as proposing appropriate budgeting, etc. The relations between the Center bank and the curators, in addition to the verical connection of Center and Sub-banks system, make it possible to carry out the MAFF Genebank Project effectively.

3. Introduction and Collection

Introduction and collection of genetic resources was gradually accelerated, first by universities, and secondly by individual institutes such as Tropical Agricultural Research Center (TARC), MAFF. However, no systematic introduction nor collection was organized until the MAFF Genebank Project was started. The MAFF Project supports several missions every year to collect in various regions of Japan, mainly for minor and vegetative crop species. International expeditions for germplasm collection are carried out by cooperation with local research organizations. Since 1983, we have sent 4-5 missions abroad every year, and made joint teams with local institutes for field collection and exploration by direct support of the Project

(Table 4). Additionally, international missions were actively organized by different budget sources from IBPGR, TARC, Japan International Cooperation Agency (JICA) and others (Tables 5).

4. Preservation

In 1968, we constructed the first modern genebank for multi-crop species at Hiratsuka. This walk-in type bank had the first system for duplicate preservation of seeds, i.e., long-term preservation for permanent and original stocks and medium-term for distribution to users. After ten years, a new bank with a robotic system was established at Tsukuba in 1978. The new bank had also two types of rooms with different conditions to preserve seed for long-term (-10℃, 30%RH) and for medium-term (-1℃, 30%RH) for distribution. After a few years we soon faced a shortage of storage capacity. NIAR then constructed the third-generation genebank with a complete robot system in 1988. The earlier bank was rebuilt after completion of the third one in 1991 to facilities for extended long-term storage and original seed stocks.

Vegetatively propagated plants need a enebank in the field or a cellbank. The former are still important to maintain fruit trees, tea, mulberry, and other vegetable crop species. The Center Bank and many Sub-banks located at suitable places are assigned to preserve their specific crops.

Cryopreservation techniques make it possible to preserve effectively plant cells, tissues, orthodox seeds for base collection and some recalcitrant seeds. The combination of a liquid nitrogen tank and a programmable freezer is the latest technical improvement, used to bulid a system for long-term preservation in ultra-low temperatures (-196～-160℃). The technique for the cryopreservation is adopted for not only microorganisms nor animal cells, but for important base collections of plant seeds. The capacity of them is still under developing.

All kinds of accessions preserved in the Project are classified into three types: base, active and working collections. Base collections are the accessions registered for long-term preservation as originals, while active collections are for distribution to users, as shown in Table 6. The working collections are still maintained at the laboratory level, in addition to those plants registered in the base collection.

5. Evaluation and Data Management

Strict characterization and evaluation of genetic resources is required for utilizing them as breeding materials, experimental lines and various other unexpected uses. Evaluation data, if extensive enough and easily available for users must be helpful for parctical use. Nevertheless, evaluation duties are not always welcomed by researchers, because they are hard and dull work.

The MAFF Genebank Project designates three levels of evaluation for each crop species, i.e., primary, secondary and specific characters, depending on the extent of importance in utilization and complication in measuring. The descriptors for the primary evaluation are limited in number to ca. ten characters as essential items. The secondary characters include resistance genes for pests and diseases, detailed agronomic traits, such as some quantitative characters and stress tolerance. The specific characters are, e.g., amylose content of cereal endosperm, enzyme activities/electrophoretic zymogram patterns, grain quality, productivity or yield of production, and etc. A record of accessions primarily evaluated in recent years is shown in Table 7.

To develop data management systems is indispensable for handling germplasm materials collected worldwide, for constructing inventory database and for utilizing evaluation data. The MAFF Project has established management systems for passport data processing, conservation/distribution of plant germplasm materials and evaluation/characterization.

6. Distribution, Exchange and Utilization

The aim of collecting, evaluating and preserving germplasm is to utilize in plant breeding and the other practical use. The process of modern plant breeding needs several steps for adding new traits, as well as exotic germplasm with detailed data. The current situation is not ideal for the breeders, but our research on plant genetic resources is directed for that goal. As records of accessions distributed from the MAFF Project show (Table 8). MAFF germplasm materials were used by not only national institutes, but also by universities, prefectural institutes, private sectors and organizations abroad.

Utilization of plant genetic resources in breeding has reached a new phase. Artificial gene transfer and recombinant DNA methods in biotechnology need new genes from well preserved materials and

accumulated research results in each crop species. The rapid development of the " Rice Genome Project " at NIAR is a good example.

7. International Exchange and Cooperation

Thinking of the size of our planet, international cooperation on plant genetic resources becomes important naturally. Networking for practical solutions is guided by IBPGR (IPGRI) and international institutes for agriculture. NIAR and cooperating institutes have been appointed as registered genebanks for the international base collection of many plant species, Japanese specialists have been participating in the IBPGR collecting missions every year. JICA, the Japan International Cooperation Agency, has also contributed much in this field by assisting establishment of genebanks and the storage facilities in Bangladesh, Thailand, Sri Lanka, Chile, Myanmar, Pakistan, etc. International training course on plant genetic resources is also one of the activities sponsored by JICA. We received 113 scientists from 24 countries until the 1 lth class in 1992.

8. The Second Phase of the Project and the Prospects

Technology of modern agriculture has reduced extent of genetic diversity and accelerated the genetic erosion in various crop species. Because of the serious environmental disruption worldwide, the ecological situation for even the wild species is going from bad to worse. New approaches will become important both for maintaining the biodiversity of plant resources and for preventing the extinction of important plant species.

The second phase of the MAFF Genebank Project was started at the beiginning of April 1993 as another 8-year plan in all areas of the genetic resources, i.e., 1) plants, 2) microorganisms, 3) animals, 4) forest trees and 5) fisheries organisms. It aims at accumulation of data on detailed characteristics, at further development of database management, at international cooperation of research exchange. Moreover, corresponding to a rapid development of the " Rice Genome Program " at NIAR, the DNA-bank Program has been initiated in 1993 for the sixth category of the MAFF Genebank Project. They are national programs, however beyond a nation if we thought the present status on the environment surrounding us. Ultimately, more attentiion must be directed to ecological aspects, so as to maintain our planet for all living creatures.

Table 1. Plant Genetic Resources System in MAFF

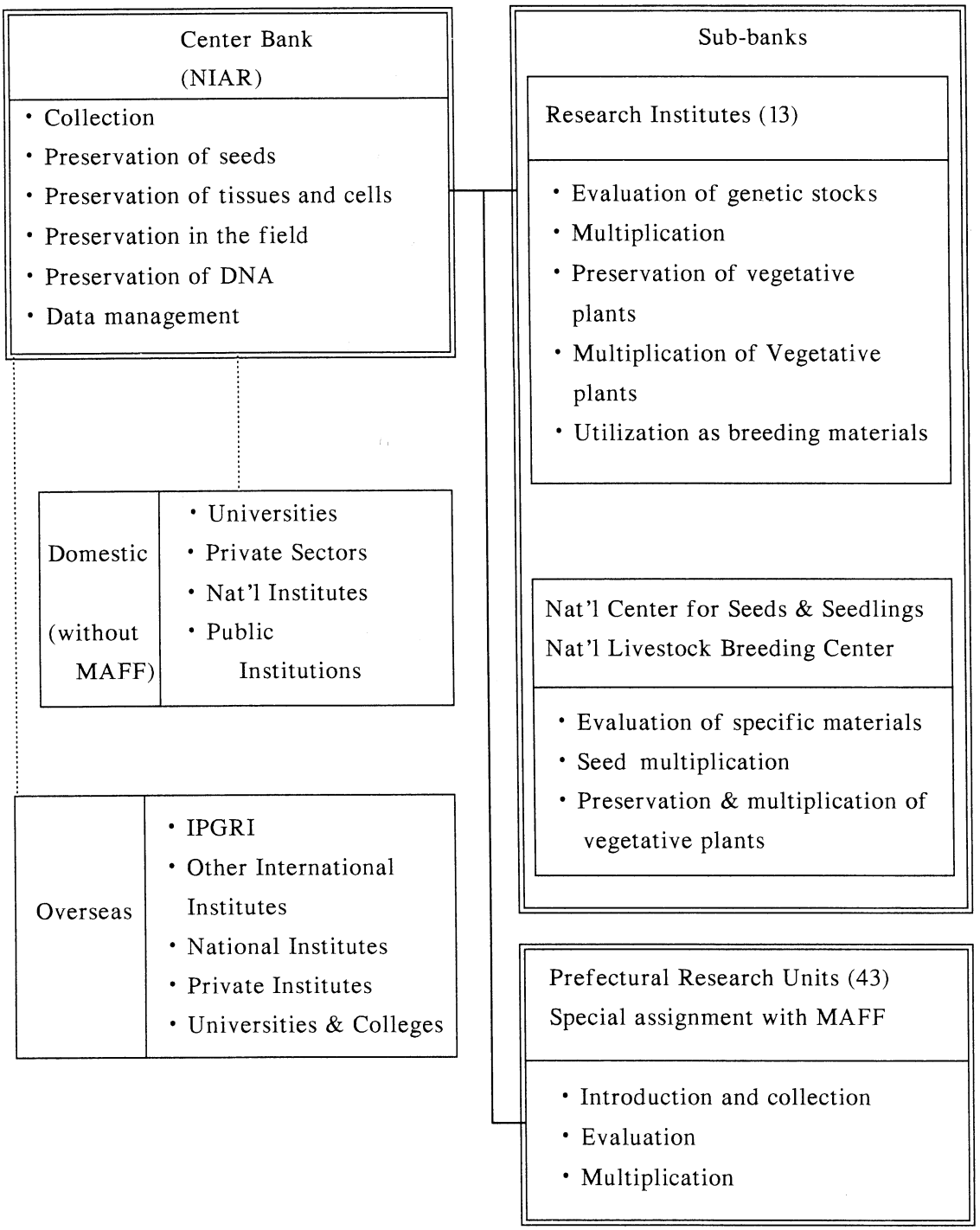

Table 2. Network of MAFF Genebanks

Center Bank = National Institute of Agrobiological Resources (NIAR. Tsukuba)

Sub-banks

Prefectural Research Units with special assignment = 43 Units

MAFF Organizations (15) Name of Sub-Bank (abbr., location)	Crop species	No. of Units Labs
National Agriculture Research Center (NARC, Tsukuba)	Rice, Wheat, Soybean. Sweet potato. Millet, etc.	11
National Institute of Agrobiological Resources (NIAR, Tsukuba)	General and Rice etc.	11
National Grassland Research Institute (NGRI, Nishinasuno)	Forage plants, Maize, etc.	5
Fruit Tree Research Station (FIRS, Tsukuba and branches)	Fruit trees	10
National Research Institute of Vegetables, Ornamental Plants and Tea (NIVOT, Anou and branches)	Vegetables, Tea, Ornamental plants	20
Hokkaido Agricultural Experiment Station (HNAES, Sapporo & branches)	Rice, Fruit trees, Forage crops, Root crops, etc.	14
Tohoku Agricultural Experiment Station (TNAES, Morioka & branches)	Rice, Soybean, Oil seed, Mulberry, etc	8
Hokuriku Agricultural Experiment Station (HNAES, Joetsu & branches)	Rice, Forage crops, etc.	5
Chugoku Agricultural Experiment Station (CNAES, Fukuyama)	Rice, Wheat, Sorghum, etc.	5
Shikoku Agricultural Experiment Station (SNAES, Zentsuji)	Rye, Wheat	2
Kyushu Agricultural Experiment Station (KNAES, Nishigoshi & branches)	Rice, Wheat, Barley, Sugarcane, Root crops	13
National Institute of Sericultural and Entomological Sciences (NISES, Tsukuba)	Mulberry	3
Tropical Agricultural Research Center (TARC, Tsukuba & Ishigaki)	Tropical crops, Rice, etc.	4
National Center for Seed & Seedlings	Oats, Fruit trees, Potato, Tea, etc.	Farms 13
National Livestock Breeding Center	Forage crops, Maize, etc.	Ranches 3
		Total 170 Labs & units

Table 3. Curators of Plant Genetic Resources in MAFF Genebank

- Introduction, Collection
- Evaluation, Multiplication
- Preservation
- Data management

NIAR Labs in Center Bank

Crop group	Crops targetted	Curator (Chief of lab shown below)
01 : Rice	Rice and related species	Rice Breeding Technology Lab., NARC
02 : Wheat & Barley	Wheat, Barley, related species	Wheat and Barley Technology Lab., NARC
03 : Legumes	Soybean, Adzuki, other beans & nuts	Legume Breeding Lab., NARC
04 : Tuber crops	Sweet potato, Potato, others	Sweet Potato Breeding Lab., NARC
05 : Millet & Industrial crops	Miscellaneous cereals Oil crops, etc.	New Crop Breeding Lab., NARC
06 : Forage crops	Forage crops	Breeding Material Lab, NGRI
07 : Fruit trees	Fruit trees	The 4th Lab of Breeding, FTRS
08 : Vegetables	Vegetables	The 4th Lab of Breeding, NIVOT
09 : Ornamental plants	Flower plants and other ornamentals	The 1st Cut Flower Lab of NIVOT
10 : Tea	Tea plants	Breeding Lab, Tea Cultivation Div., NIVOT
11 : Mulberry	Mulberry plants	Mulberry Breeding Technology Lab., NISES
12 : Tropical plants	Tropical and Sub-tropical plants	Crop Introduction Lab, TARC

Table 4. International collecting missions organized by MAFF Genebank Project*

Year	Areas	Target plants
1980	1:European countries	*Beta,* Potato
1981	1:Ivorv Coast. India	Rice, Sorghum
	2:Papua New Guinea, Solomon Is.,	Taro, Yam, etc.
Fiji		Ryegrasses, Alfalfa, etc.
1982	1:Italy, France	*Amorphophallus conjac*
1983	1:Thailand, Philippines	Soybean
	2:Indonesia	Wheat, Barley
	3:Turkey, Egypt	Tomato, Pimento
	4:Mexico, Costa Rica, Peru, Bolivia	Rice
	5:Bangladesh	Tea
1984	1:India, Thailand, Indonesia	Grapes, etc.
	2:North America	Rush
	3:New Zealand	*Vigna* spp.
	4:Korea (s.)	*Prunus. Pyrus, Diospyros*
1985	1:Taiwan	Wheat, Barley
	2:Italy, Hungary	Sweet potato, Sugarcane
	3:Papua New Ginea	Peanut, Maize
	4:Argentine	Soybean
	5:Thailand	Forage plants
1986	1:Morocco, Portugal, Spain	Rice
	2:Thailand	Root crops, Vegetables
	3:Peru, Ecuador	Small millets
	4:Tanzania	Vegetable crops
	5:Thailand	Vegetables
1987	1:Nigeria	*Vigna* spp.
	2:Nepal	Wheat, Barley
	3:Morocco, Syria	Citrus, Barley
	4:Italy, Greece, Israel	Citrus, Loquat, etc.
1988	1:Nepal	Rhododendron, Lilium
	2:India	Sugarcane
	3:Argentina	Alfalfa
	4:Indonesia	Upland rice
1989	1:Algeria	Wheat, Barley
	2:Malaysia, Thailand	Sweet potato
	3:France, Italy	Grapes
	4:Greece	Tulip, Allium
1990	1:Morocco, Spain	Wild *Beta*
	2:Finland, Sweden	Forage plants
	3:Thailand	Rice
	4:Malaysia	Food legumes
1991	1:USSR	Forage plants
	2:Poland	Vegetables
	3:Sri Lanka, Thailand	Millets
	4:Uruguay, Chile	Root crops
1992	1:Brazil	Pineapple
	2:Mexico	Mulberry
	3:India	*Seasmum*
	4:Madagascar	Rice

*: MAFF Genebank Project, i.e. Genetic Resources Project, MAFF is coordinated by NIAR under AFFRC, MAFF. The Missions funded by the project are internationally conducted including a Japanese team leader, Japanese members and members from host countries.

Table 5. Collecting missions with other funds (selected. led by Japanese Team Leaders)

Time	Fund and status	Area	Crop or Genus
1980	TARC, Bilateral	Mexico, Costa Rica, Peru, Brazil, Ecuador, Colombia, Panama	Tuber crops
1982	TARC, Bilateral	Papua New Guinea, Fiji, Solomon	Tuber crops
1983	IBPGR, International	Thailand	Citrus spp.
1983	TARC, Bilateral	Malaysia, Thailand	Tropical vegetables
1983	IBPGR, International	Vietnam, Laos	Food legumes
1984	IBPGR, International	Thailand, Malaysia	Citrus spp.
1984	IBPGR*, International	Nepal	Cereals, Fruits, Vegetables
1985	TARC, Bilateral	Colombia	Forage crops
1985	IBPGR*, International	Nepal	Cereals, Fruits, Vegetables
1985	TARC, Bilateral	Philippines, Malaysia	Tropical vegetables
1986	IBPGR*, International	Thailand, Indonesia	Citrus spp.
1986	IBPGR*, International	Papua New Guinea	Tuber crops
1987	TARC, Bilateral	Syria, Turkey	Food legumes
1987	IBPGR*, International	Papua New Guinea	Tuber crops
1988	IBPGR, International	Indonesia	Citrus spp.
1989	TARC, Bilateral	Thailand	Tropical fruits
1989	IBPGR*, International	Pakistan	Cereals, Legumes, Millets
1990	TARC, Bilateral	Cote d'Ivoire, Tanzania, Kenya	Forage crops
1990	TARC, Bilateral	Indonesia, Thailand	Tropical fruits
1991	IBPGR*, International	Pakistan	Cereals, Legumes, Millets
1992	TARC, Bilateral	Indonesia	Fruit trees
1992	IBPGR*, International	Russia & neighboring republics	Fruits, Forage
1993	TARC, Bilateral	Indonesia	Sugarcane
1993	IBPGR*, International	Russia & neighboring republics	Wheat, barley,
1993	IBPGR*, International	-do.-	Legumes, Vegetables, etc.

TARC : Funded by Tropical Agricultural Research Center, AFFRC, MAFF.

IBPGR : Funded by IBPGR as International mission.

IBPGR* : Organized by IBPGR with special funds of Japanese government.

Table 6. Present Status of Preservation of Plant Genetic Resources under the MAFF Genebank (1992)

Crop group	No. of accessions preserved			Collection preserved vegetatively
	Total collection	Base collection	Active coll.	
Rice	26, 570	22, 695	16, 744	120
Wheat and barley	54, 509	50, 035	23, 242	274
Food legumes	14, 688	12, 395	8, 605	0
Root and tuber crops	5, 667	4, 780	3, 548	5, 023
Millet oill & industrial crops	9, 728	7, 553	5, 583	2, 092
Forage plants	42, 444	17, 441	11, 052	8, 853
Fruit tress	7, 851	5, 553	3, 832	7, 850
Vegetables	20, 540	11, 648	5, 816	1, 366
Flower and others	2, 864	842	239	2, 857
Tea plants	5, 353	4, 354	496	5, 353
Mulberry	1, 855	1, 406	209	1, 855
Tropical crops	791	127	126	121
Total	192, 860	140, 829	79, 492	35, 764

Table 7. A Record of Accessions Evaluated Primarily under the MAFF Genebank Project in Recent Years

Crop group	1986	1987	1988	1988	1990	1991	1992
Rice	1, 194	1, 307	1, 021	902	914	1, 093	1, 420
Wheat and barley	3, 086	3, 296	5, 387	5, 132	3, 010	3, 708	3, 576
Food legumes	328	433	512	484	550	546	802
Root and tuber crops	723	4, 800	4, 336	5, 311	4, 170	4, 710	4, 899
Millet, oil & other crops	424	974	984	749	1, 346	1, 614	2, 764
Forage plants	869	1, 169	1, 947	1, 410	3, 157	1, 706	2, 595
Fruit tress	572	854	1, 124	681	657	760	613
Vegetables	833	777	968	865	897	2, 233	1, 141
Flower and others	475	330	216	303	853	488	420
Tea plants	280	294	474	474	1, 588	1, 934	3, 328
Mulberry	145	260	375	431	285	276	243
Tropical crops	50	121	23	89	44	44	29
Total	8, 979	14, 615	17, 367	16, 831	17, 471	19, 112	21, 830

Table 8. Records of Accessions Distributed in Recent Years

Year	Acc. distributed to national organizations			Abroad	Total
	Institute	University	Private sector		
1985	198	0	57	266	521
1986	4, 515	1, 344	295	811	6, 965
1987	9, 811	356	432	1, 548	12, 138
1988	3, 472	229	735	1, 309	5, 745
1989	14, 082	480	397	254	15, 213
1990	5, 651	896	482	373	7, 402
1991	5, 394	850	380	691	7, 315
Total	43, 123	4, 155	2, 769	5, 252	55, 299